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ABSTRACT

The question of whether to teach computer programming to elementary and secondary students has been widely debated. This study examines the relationship between computer programming experience, mathematics experience, and general variable skill. The sample consisted of 46 students (aged 9 to 17) at a summer computer camp. The programming level was determined from results of a camp placement test as novice, intermediate, or advanced. Mathematics experience was defined as the number of years of algebra-and-above courses that students had completed. Variable skill was determined from scores on the General Variable Skill Test. This study reports that both computer experience and mathematics experience were significantly correlated with general variable skill. Further, the relationship of computer programming experience with general variable skill was stronger than the relationship of mathematics experience with the variable skill. (YP)

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General Variable Skill, Computer Programming and Mathematics

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General Variable Skill, Computer Programming and Mathematics

The question of whether to teach computer programming to precollege students has been widely debated. It seems that if computer programming is to become a part of the general curriculum, there must be evidence of positive transfer effect from computer programming to other content areas. Since both advanced mathematics and computer programming make extensive use of variables, it appears likely that this skill could transfer. Programming languages use algebraic variables in a manner similar to their mathematical use, but give them an "operational" context. Given the fact that many mathematics students have difficulty with algebraic variables, it may be that this area is the most important short-term effect of computer programming instruction.

In an informal study, Hart (1982) observed that children who had previous computer programming courses performed better on algebra tests. His explanation was that programming helps students to see "letters as labels of stores whose contents can vary" (p. 52).

Soloway, Lochhead, and Clement (1982) studied the relationship of computer programming and the use of variables. Previous studies had found that college engineering students had difficulty in correctly representing relationships in algebraic equations (Clement, 1982; Clement Lochhead, & Monk, 1981). Soloway et al. (1982) designed two experiments which sought to

find out whether students would have similar difficulties with computer programs and with algebra equations in this area. In the first experiment, two groups of college computer students were given the same problem, but were asked to express it as either an equation or a program. Significantly more subjects in the programming condition were able to express it correctly. In the second experiment, two groups of college subjects were asked to "write a sentence in English" to express the relationship given in both an equation and a program. The number of students who got the equation correct and the program incorrect was significantly less than the number of students who got the program correct and the equation incorrect. The conclusion was that computer programs facilitate the understanding of algebraic variables.

Oprea (1985) studied the effects of programming instruction on generalization and understanding of variable. Her sample was three intact groups of sixth graders who received six weeks of programming instruction. The groups were (1) wholistic (taught at the whole program level for mathematically relevant problems), (2) elemental (taught the individual commands necessary to write a complete program), and (3)control (no programming instruction). She developed instruments for measuring programming ability, generalization, and understanding of variables. Using analysis of covariance to control for pretest scores, she found that both of the programming groups scored significantly higher on all three measures than the control group. She concluded that programming enhances generalization and understanding of

variable. There was no effect for the different instructional methods.

McCoy (1986) studied 21 students, ages 10 to 17, at a summer computer camp. At the end of a 2-week intensive program of BASIC instruction, she found that they showed a significant improvement in ability to use mathematical variables and mathematical problem solving. These gains were measured pre and post by subtests of the Algebra Readiness Test. Again there was no control group, but the results are an indication of a possible effect.

Mayer (1975, 1976, 1979, 1985) explained computer operation in terms of transactions. A transaction is an event in the computer that involves some operation on some object at some location. He proposed that this concrete representation would make programmers better able to understand and use algebraic variables. This idea was verified in a subsequent study (Mayer,Dyck, & Vilberg, 1986), where experienced programmers were found to have a better understanding of and facility with mathematical variables. The participants were college students in a beginning BASIC course. When compared with a control group, the BASIC students gained significantly more in word problem translation, word problem solution, and procedure comprehension. They concluded that all of these specific skills are components of general problem solving, and therefore, BASIC instruction improves problem solving.

The above studies provide evidence that computer programming improves understanding and skill in algebraic variables. In studies of young children (Hart, 1982), secondary school students

(McCoy, 1986; Oprea, 1985), and college students (Mayer et al., 1986; Soloway et al., 1982;), experience in computer programming was found to have a positive effect on the knowledge of algebraic variables.

The present study examined the relationship between computer programming experience, mathematics experience, and general variable skill.

Method

Sample

The sample consisted of 46 students (aged 9 to 17) at a summer computer camp. All students at the camp were included in the sample. Ability levels were varied, as was background in both computer programming and mathematics.

Variables

Programming level (novice, intermediate, or advanced; coded 1,2,3) was determined from results of the camp placement test. This test consisted of three programming problems to be completed in either BASIC or Pascal. Scoring was done by the camp instructional staff and was based primarily on ability to apply programming concepts. The level was the basis for instructional grouping for the camp program.

Mathematics experience was defined as the number of years of higher mathematics courses (algebra and above) that they had

successfully completed. This information was provided by the participants.

Variable skill was determined from scores on the General Variable Skill Test, which consisted of 15 multiple choice items where verbal situations were described and the student selected the equivalent variable expression.

Results and Conclusions

Means and standard deviations of all variables are presented in Table 1. Both computer experience and mathematics experience

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Insert Table 1 here
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were significantly correlated with general variable skill (See Table 2). Further analysis involved use of multiple regression

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Insert Table 2 here
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analysis to identify the unique relationships, i.e. to examine the relationships of mathematics and computer experience in combination on general variable skill. Results indicated that when general variable skill was regressed on the two experience variables, computer programming experience was a significant predictor and mathematics experience was not (See Table 3).

Insert Table 3 here

The results of this study indicated that computer programming experience had a significant relationship with

general variable skill. Further, this relationship was stronger than the relationship of mathematics experience with general variable skill. It should be emphasized that the General Variable Skill Test was not in a programming format, but consisted of mathematics-type story problems.

These results must be viewed as tentative for two reasons. First, the nature of correlation/regression analysis does not provide evidence of causality, only observed relationship. Therefore, we cannot say that it was the programming skill that transferred to variable skill, only that the two are significantly related. And second, the sample size in this study was small. Despite these weaknesses, this study is important preliminary evidence of a positive effect on general variable skill from computer programming.

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Table 1.
Means and Standard Deviations of All Variables.

	Mean	Standard Deviation
General Variable Skill	12.5	3.22
Mathematics Experience	1.15	1.15
Computer Programming Experience	1.7	0.76

N=46

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Table 2.
Correlation Matrix for All Variables

	General Variable Skill	Mathematics Experience	Computer Prog. Experience
Gen. Variable Skill	1.000	.463	.555
Mathematics Experience	.463	1.000	.496
Computer Prog. Experience	.555	.496	1.000

N=46

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Table 3.
Regression Results for Predicting General Variable Skill

Independent Variable	Regression Coefficient	Standardized Coefficient	t	Probability Level
Computer Prog. Experience	1.837	.431	3.06	.004
Mathematics Experience	.695	.249	1.76	.085

R Squared = .35

N=46